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COST ANALYSIS OF NEDU'S HELIUM RECLAIMER,(U)
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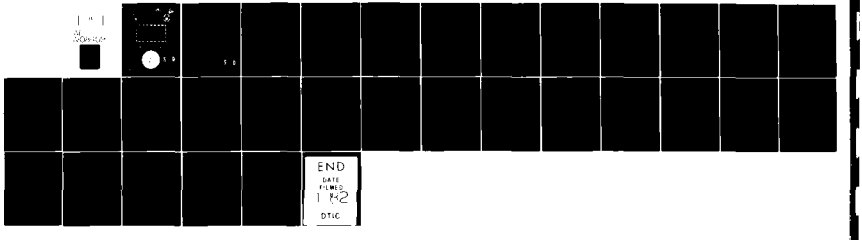

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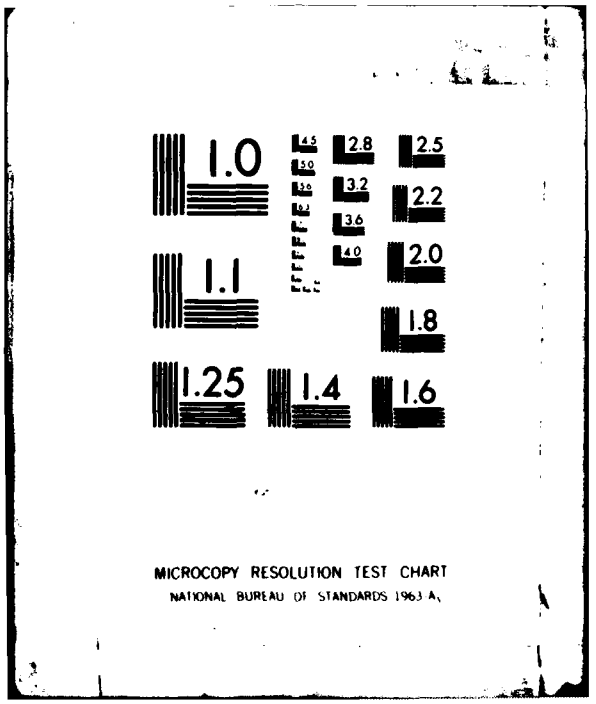
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DEPARTMENT OF THE NAVY
NAVY EXPERIMENTAL DIVING UNIT
PANAMA CITY, FLORIDA 32407

NAVY EXPERIMENTAL DIVING UNIT

REPORT NO. 9-81

COST ANALYSIS OF NEDU'S HELIUM RECLAIMER

ERIC RANDALL

SEPTEMBER 1981

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UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NEDU 9-81	2. GOVT ACCESSION NO. AD-A108409	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) COST ANALYSIS OF NEDU'S HELIUM RECLAIMER		5. TYPE OF REPORT & PERIOD COVERED Survey
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) ERIC RANDALL		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS NAVY EXPERIMENTAL DIVING UNIT PANAMA CITY, FLORIDA 32407		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE September 1981
		13. NUMBER OF PAGES 27
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The analysis compares the cost effectiveness of reclaiming helium from the Navy Experimental Diving Unit's (NEDU) Ocean Simulation Facility (OSF) Hyperbaric Chamber Complex using a Helium Reclamation System manufactured by DIVETEC Systems, Inc. to purchasing pure helium from the U.S. Department of the Interior Bureau of Mines. The cost of electrical power, maintenance and upgrade of the Helium Reclaim System is considered along with the effects of various inflation rates. A discounted cash flow analysis is provided.

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S/N 0102-014-6601

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Abstract

The analysis compares the cost effectiveness of reclaiming helium from the Navy Experimental Diving Unit's (NEDU) Ocean Simulation Facility (OSF) Hyperbaric Chamber Complex using a Helium Reclamation System manufactured by DIVETEC Systems, Inc. to purchasing pure helium from the U.S. Department of the Interior Bureau of Mines. The cost of electrical power, maintenance and upgrade of the Helium Reclaim System is considered along with the effects of various inflation rates. A discounted cash flow analysis is provided.

I. INTRODUCTION

The analysis compares the cost effectiveness of reclaiming helium from the Navy Experimental Diving Unit's (NEDU) Ocean Simulation Facility (OSF) Hyperbaric Chamber Complex using a Helium Reclamation System manufactured by DIVETEC Systems, Inc. to purchasing pure helium from the U.S. Department of the Interior Bureau of Mines. The cost of electrical power, maintenance and upgrade of the Helium Reclaim System is considered along with the effects of various inflation rates. A discounted cash flow analysis is provided.

II. BACKGROUND

In this analysis the following assumptions are made:

1. Life of equipment is assumed to be 15 years optimal.

2. Inflation on helium delivery charges is assumed to be between 2 and 10% per year.

3. Fee for demurrage is $100.00 per day, and the average cost of a 3 day retainer is figured into the transportation cost.

4. Initial cost of the reclaimer is not included.

5. Inflation of the price of electricity is estimated between 5 and 20% per year.

6. Reclamation of 540,000 ft^3/He per year (assumed).

7. Loss of 10% of gas through the reclaimer (assumed).

8. Change filters every 70,000 ft^3/He reclaimed.

9. Manpower operating cost not included (military Labor).

The cost of high-purity helium has remained constant for the last few years and, based on Bureau of Mines forecast, will remain constant for the foreseable future. The only anticipated increase will be the cost of delivery which will vary with fuel prices. High-purity helium presently costs NEDU $52.80 per 1000 cubic feet.

The major factor which will affect the cost of reclaiming helium in the future is the electric power rates. Local power companies indicate that their electric rates have followed the national inflation rate in the past and will continue to do so in the future. Therefore a per annum inflation rate of approximately 12% is a reasonable assumption.

In this analysis the labor cost to run and maintain the Helium Reclaimer and its supporting hardware (compressors, storage bag, valves, regulators, etc.) is negligible. However, it is estimated that both the Reclaimer and compressor will each require 1/2 hour of periodic maintenance for every 70,000 cubic feet of impure helium processed.

During NEDU's DEEP DIVE 81, a 28 day, 1000 FSW dive, the Reclaimer was operated on a limited basis to analyze its reclamation abilities. The helium was of high quality and will be further discussed later.

The following problems must be rectified on the existing Reclaimer. The cost of rectifying these problems is included in the analysis and are described as follows:

1. The user's manual supplied with the Helium Reclaimer is out of date. An up to date manual should be procured.

2. Four flowmeters, of the rotameter-type, must be installed to regulate and calibrate the Reclaimer gas flow to the analysis equipment. The cost is approximately $150 each and then may be purchased from a variety of vendor sources.

3. One or two volume tanks, with a total capacity of 400 cubic feet, is required in-line between the compressor and the Reclaimer. This volume tank is required as a buffer reservoir to maintain the 2000 psig pressure required by the Reclaimer during bed shifting. The tanks should be high pressure cylinders and can be purchased for approximately $420 each.

4. A helium recovery collection bladder is required. The bladder should have a minimum capacity of 1300 cubic feet at atmospheric pressure. The ideal location for the bladder should be at ground level. The FABRICO Manufacturing Co. can manufacture the bladder for approximately $1600.

5. Approximately $500 will be required for installation of additional piping.

Overall Reclaiming System maintenance cost also must be considered. The compressor will incur maintenance cost of approximately $150 per year and another $700 every 5 years. The Helium Reclaimer will require $2100 per year. This is based on reclaiming approximately 540,000 cubic feet of impure helium per year.

It is assumed that NEDU receives approximately 900,000 cubic feet of helium per hyperbaric operation (deep saturation dives). Assume that 40% of this helium is used for medical lock excursions, mixed-gases for diver breathing purposes, treatment gases and emergency gases and assorted unmanned testing and system leakage. Of the 540,000 cubic feet available for reclamation, approximately 10% will be lost in the reclaiming process, leaving 486,000 cubic feet of clean reclaimed helium. This will be the total volume of cleaned gas used in the analysis.

III. DISCOUNTED CASH FLOW MODEL

A dollar in the hand today is worth more than a dollar to be spent five years from today, because the use of money has a cost. Because the discounted-cash-flow model explicitly and systematically weights the time valve of money and is therefore helpful in making long range decisions, it was the method chosen to assist in the analysis (Section VI, Item 5).

The present cost used is the total cost over 'N' years brought back to equivalent dollars in todays economy. The future cost is the total cost over 'N' years brought forward to equivalent dollars in the economy, 'N' years in the future. Equal annual cost is the cost of the present or future cost distributed equally over 'N' years.

IV. RESULTS

The results of the gas analysis of the helium reclaimed during DEEP DIVE 81 were positive and very encouraging. All of the gas analyses results indicate at least a 99.84% helium (see Appendix 1).

The cost analysis results are also very encouraging. Assuming that the delivery rate for helium increases at 2% per year, the inflation rate for electric power rates can climb to 15% per year and without affecting the Helium Reclaim cost effectiveness. This is assuming a 6% per year inflation rate on maintenance and neglecting in-house labor costs. The cost for maintenance varies directly with the amount of helium reclaimed. The overall inflation rate of 12% per year, used to calculate present, future and equivalent yearly payments, was used as a constant. If the actual inflation rate does vary, the cost difference between the reclaimed gas and the purchased gas will also vary but will not affect the overall cost effectiveness of reclaiming helium.

The costs of purchasing helium and reclaiming helium for different inflation rates are shown in Figure 1.

V. CONCLUSION

The cost analysis illustrates that NEDU's Helium Reclaimer is cost effective, i.e., the net present worth is positive in all cases. It has also been demonstrated that the Helium Reclaimer can effectively clean impure helium well above the required specifications.

VI. REFERENCES

1. Herb Gershner, U.S. Bureau of Mines, Helium Operations, Amarillo, Texas, 31 Aug 81 (telephone conversation).

2. Gulf Power Company, Panama City, Florida, 2 Sep 81 (telephone conversation).

3. Dan McNeil, NEDU, 31 Aug 81 (telephone conversation).

4. Dan McNeil, NEDU, 31 Aug 81 (telephone conversation).

5. Charles T. Horngren, "Introduction to Management Accounting" Fourth Edition.

FIGURE 1

PRESENT, FUTURE AND EQUAL ANNUAL COST OF PURCHASED HELIUM

INFLATION RATE OF HELIUM DELIVERY	PRESENT COST (1981)	FUTURE COST (1996)	EQUAL ANNUAL COST (YEARLY)
2	$208,072.15	$1,138,903.72	$30,545.40
5	$221,998.05	$1,215,128.53	$32,589.75
10	$254,200.74	$1,391,393.17	$37,317.17

PRESENT, FUTURE AND EQUAL ANNUAL COST OF RECLAIMED HELIUM

INFLATION RATE OF ELECTRICITY	PRESENT COST (1981)	FUTURE COST (1996)	EQUAL ANNUAL COST (YEARLY)
5	$112,092.51	$ 613,549.56	$16,455.40
8	$118,979.70	$ 651,247.29	$17,466.45
10	$141,805.18	$ 776,184.83	$20,817.28
12	$157,558.97	$ 862,414.78	$23,129.96
15	$186,710.29	$1,021,977.44	$27,409.44
20	$255,090.14	$1,396,261.39	$37,447.73

VII. CALCULATIONS

Power = I^2R = IV = V^2/R
in Units of WATTS or JOULES/SEC

Energy = (Power) (Time)
in Units of JOULES or KW-HR

Present Cost of Power to NEDU = 0.0541 ¢/KW-HR

Cost to Run Reclaimer for 1 Hour:

(15 A) (110 V) = 1650 W = 1.65 KW
(1.65 KW) (3600 SEC) = 5940 KJ (= KW-HR)
(5940 KW-HR) (.0541 ¢/KW-HR) = 3.214 $/HR

Cost to Run Compressor for 1 Hour:

(32 A) (220 V) = 7040 W = 7.04 KW
(7.04 KW) (3600 SEC) = 25,344 KW-HR
(25,344 KW-HR) (.0541 ¢/KW-HR) = 13.711 $/HR

Total Cost:

(13.711 + 3.214) = 16.93 $/HR

Flow Through Reclaimer in 1 Hour:

(20 SCFM) (60 MIN/HR) - (10%) (20.60) = 1080 SCFH

Cost Per 1000 FT^3/He Reclaimed:

[(16.93 $/HR) / (1080 SCFH)] (1000 FT^3) = 15.67 $ PER 1000 FT^3

To include cost of pre and post-cleaning of reclaimer, assuming its run in 4000 FT^3 increments of helium:

($15.67 PER 1000 FT^3) + (0.25) (3.214 $/HR) $\frac{1 \quad HR}{1080 \ FT3}$ = 16.42 $ PER 1000 FT3

Cost of Power in 15 Years at Different Inflation Rates:

5%	>	31.03	$ PER 1000 FT^3
10%	>	59.51	$ PER 1000 FT^3
12%	>	76.58	$ PER 1000 FT^3
15%	>	96.41	$ PER 1000 FT^3
20%	>	167.66	$ PER 1000 FT^3

Future Worth = (Present Worth) (F/P, i%, N)

i% = Interest Rate

N = Number of Years

F/P = Factor $(1 + i\%)^N$

APPENDIX A

GAS ANALYSIS RESULTS

APPENDIX A

HELIUM RECLAIMER SPECIFICATIONS

Inlet Flow	15-25 scfm
Design Pressure	2400 PSI
Inlet Pressure	2100 psig minimum
Inlet Impurities	O_2-20% max including N_2
	N_2-30% max including O_2
	CO_2-1% max
	CO-20 ppm max
	Water Vapor-saturation @ 90°F & 2100 psig
	Hydrocarbons - 100 ppm max
Outlet Purity	He- 99.5% min
	O_2- .5% max including N_2
	N_2- .5% max including O_2
	CO_2-2ppm or less
	Water Vapor - 2 ppm
	Hydrocarbons - 1 ppm
Life of Disposable Cartridges	100,000 scf/min
Weight	1800 lb
Dimensions	50"W x 78"D x 60"H
Power	Electrical - 15 amps, 110V, 60 cycle, single phase
	Air - 60 psig, filtered
	Pure Helium - 100 psig (start-up only)
Instrumentation	Oxygen Monitor with Alarms
Switching Control	Automatic sensor control senses when molecular sieve filter bed becomes contaminated and switches flow stream to the next clean bed.

APPENDIX A

U.S. BUREAU OF MINES HELIUM OPERATIONS
HIGH-PURITY HELIUM

SPECIFICATIONS

Impurity	Maximum Concentration PPM by Volume
Neon	23
Nitrogen	5
Oxygen	3
Water Vapor	
In-tank Cars or Trailers	3
In Standard Cylinder	8
Hydrogen	1
Hydrocarbons	1
Helium	> 99.997

From: U.S. Bureau of Mines,
Form HA-24 (1-77)

24 August 1981

In accordance with Mr. J. W. McCarthy's (NEDU) request of 21 August 1981, the reclaimer gas samples delivered to the gas analysis lab were analyzed and found to contain:

Component	Bed No. 1 Before Reclaimer	Bed No. 2 Before Reclaimer	Bed No. 3 Before Reclaimer	Bed No. 1 Discharge	Bed No. 2 Discharge	Bed No. 3 Discharge
CO (ppm)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total hydrocarbons (ppm)	2.5	6.7	4.2	<0.5	<0.5	<0.5
Methane (ppm)	1.4	2.4	1.8	0.08	<0.05	0.09
Halogenated hydrocarbons (ppm)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Benzene (ppm)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Methanol (ppm)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
O_2 (%)	8.06	7.67	7.85	0.034	0.0020	0.008
N_2 (%)	21.99	20.48	21.11	0.12	0.006	0.005
He (%)	69.95	71.85	71.04	99.846	99.992	99.987
CO_2 (ppm)	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0
Acetylene (ppm)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Acetone (ppm)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
112 Trichlortrifluoroethane (ppm)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
C_4^+ (ppm)	<0.3	<1.1	<0.6	<0.1	<0.1	<0.1
Ethanol (ppm)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Isopropyl alcohol (ppm)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

A. PURER
Research Chemist

Copy to:
BMC D. B. McNeil, NEDU

APPENDIX B

ECONOMICAL TABLES, CASH FLOW DIAGRAMS

APPENDIX B

COST ANALYSIS OF RECLAIMING HELIUM OVER 15 YEARS BROUGHT BACK TO A PRESENT WORTH

i Overall = 12 %/YR i' Electricity = 5, 8, 10, 12, 15 and 20 %/YR

i" Periodic Maintenance = 6 %/YR

$P.W._N = F_N$ (P/F, i %, N)

486,000 Cubic Feet of Helium is the Estimated Amount of Gas to be Reclaimed Per Year.

Sample Calculation:

N = 10, i' = 5 %/YR, i" = 6 %/YR, i = 12 %/YR

(26.75 \$/1000 FT^3) (486,000 FT^3) + (\$268.63) + (\$3760.75) = \$17029.88 = $F_N = F_10$

(\$17029.88) (P/F, 12, 10) = (17029.88) (0.3220) = \$5483.62 = $P.W._10$

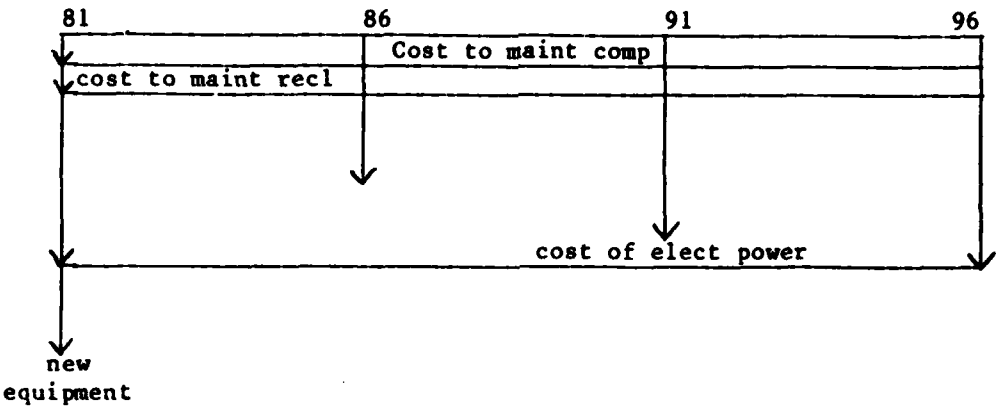
$P.W._N = P.W._TOTAL$

Future Worth:

F.W. = $(P.W._TOTAL)$ (F/P, i%, N); i% = 12 %/YR, N = 15 YR

APPENDIX B

CASH FLOW HELIUM RECLAIMED



Assumptions:

1. Initial cost of Reclaimer is a sunk cost.
2. Life of Reclaimer is 15 years.
3. Cost of periodic maintenance (Reclaimer and compresor).
4. Cost of required equipment.
5. Cost of power in future, rising at 5, 10, 15 & 20 %/YR, respectively.
6. Gas analysis cost.
7. 486,000 FT^3/He reclaimed/YR.
8. Change filters every 70,000 FT^3/He.
9. Lose 10% of gas through reclaimer.
10. 1/2 HR start-up, shut-down per run.
11. 1/2 HR Reclaimer periodic maintenance per 70,000 FT^3.
12. Neglect labor cost.
13. Add 1 extra hour of power usage per 4000 FT^3 of helium reclaimed.

APPENDIX B

$P.W._N = FN\ (P/F, I, N)$

INFLATION RATE OF ELECTRIC POWER RATE IS 5$/YEAR

INFLATION RATE OF PERIODIC MAINTENANCE IS 6$/YEAR

YEARLY NATIONAL INFLATION RATE (I) IS 12$/YEAR

YEAR	N	CUBIC FEET OF HELIUM RECLAIMED PER YEAR	COST OF ELECTRIC POWER ($/1000 FT3)	PERIODIC MAINTENANCE COST		COST OF NEW EQUIPMENT	TOTAL COST (FN)	(P/F,I,N)	PRESENT WORTH I = 12$/YEAR
				COMPRESSOR	RECLAIMER				
81	0	486,000	16.42	150.99	2,100.00	1600+500+ 600+100+ 900	13,930.12	-------	13,930.12
82	1	486,000	17.24	159.00	2,226.00	-----	10,763.64	0.8929	9,610.85
83	2	486,000	18.10	168.54	2,359.56	-----	11,324.70	0.7972	9,028.05
84	3	486,000	19.01	178.65	2,501.10	-----	11,918.61	0.7118	8,483.67
85	4	486,000	19.96	800 + 189.37	400 + 2,651.18	-----	13,741.11	0.6355	8,732.48
86	5	486,000	20.96	200.73	2,810.29	-----	13,197.58	0.5674	7,488.31
87	6	486,000	22.01	212.78	2,978.92	-----	13,888.56	0.5066	7,035.95
88	7	486,000	23.11	225.55	3,157.63	-----	14,614.64	0.4523	6,610.20
89	8	486,000	24.26	239.08	3,347.05	-----	15,376.49	0.4039	6,210.56
90	9	486,000	25.47	900 + 253.42	475 + 3,547.88	-----	17,554.72	0.3606	6,330.23
91	10	486,000	26.75	268.63	3,760.75	-----	17,029.88	0.3220	5,483.62
92	11	486,000	28.08	284.75	3,986.43	-----	17,918.06	0.2875	5,151.44
93	12	486,000	29.49	301.83	4,225.62	-----	18,859.39	0.2567	4,841.26
94	13	486,000	30.96	319.94	4,479.16	-----	19,845.66	0.2292	4,548.63
95	14	486,000	32.51	1000 + 339.14	550 + 4,748.03	-----	22,437.03	0.2046	4,590.62
96	15	486,000	34.14	359.48	5,032.79	-----	21,984.31	0.1827	4,016.53

P.W. TOTAL = $112,092.51

APPENDIX B

$P.W._N = FN\ (P/F,\ I,\ N)$

INFLATION RATE OF ELECTRIC POWER RATE IS 8%/YEAR

INFLATION RATE OF PERIODIC MAINTENANCE IS 6%/YEAR

YEARLY NATIONAL INFLATION RATE (I) IS 12%/YEAR

YEAR	N	CUBIC FEET OF HELIUM RECLAIMED PER YEAR	COST OF ELECTRIC POWER ($/1000 FT3)	PERIODIC MAINTENANCE COST		COST OF NEW EQUIPMENT	TOTAL COST (FN)	(P/F,I,N)	PRESENT WORTH I = 12%/YEAR
				COMPRESSOR	RECLAIMER				
81	0	486,000	16.42	150.00	2,100.00	1600+500+ 600+100+ 900	13,930.12	-------	13,930.12
82	1	486,000	17.73	159.00	2,226.00	-----	11,001.78	0.8929	9,823.49
83	2	486,000	19.15	168.54	2,359.56	-----	11,835.00	0.7972	9,434.86
84	3	486,000	20.69	178.65	2,501.10	-----	12,735.09	0.7118	9,064.84
85	4	486,000	22.34	800 + 189.37	400 + 2,651.18	-----	14,897.79	0.6355	9,467.55
86	5	486,000	24.13	200.73	2,810.29	-----	14,738.20	0.5674	8,362.46
87	6	486,000	26.06	212.78	2,978.92	-----	15,856.86	0.5066	8,033.09
88	7	486,000	28.14	225.55	3,157.63	-----	17,059.22	0.4523	7,715.89
89	8	486,000	30.39	239.08	3,347.05	-----	18,355.67	0.4039	7,413.86
90	9	486,000	32.82	900 + 253.42	475 + 3,547.88	-----	21,126.82	0.3606	7,618.33
91	10	486,000	35.45	268.63	3,760.75	-----	21,258.08	0.3220	6,845.10
92	11	486,000	38.29	284.75	3,986.43	-----	22,880.12	0.2875	6,578.04
93	12	486,000	41.35	301.83	4,225.62	-----	24,623.55	0.2567	6,320.87
94	13	486,000	44.66	319.94	4,479.16	-----	26,503.86	0.2292	6,074.69
95	14	486,000	48.23	1000 + 339.14	550 + 4,748.03	-----	30,076.95	0.2046	6,153.74
96	15	486,000	52.09	359.48	5,032.79	-----	30,708.01	0.1827	5,610.35

P.W. TOTAL = $118,979.70

APPENDIX B

$P.W._N = FN\ (P/F, I, N)$

INFLATION RATE OF ELECTRIC POWER RATE IS 8%/YEAR

INFLATION RATE OF PERIODIC MAINTENANCE IS 6%/YEAR

YEARLY NATIONAL INFLATION RATE (I) IS 12%/YEAR

YEAR	N	CUBIC FEET OF HELIUM RECLAIMED PER YEAR	COST OF ELECTRIC POWER ($/1000 FT³)	PERIODIC MAINTENANCE COST		COST OF NEW EQUIPMENT	TOTAL COST (FN)	(P/F,I,N)	PRESENT WORTH I = 12%/YEAR
				COMPRESSOR	RECLAIMER				
81	0	486,000	16.12	150.00	2,100.00	1600+500+100+600+900	13,930.12	-------	13,930.12
82	1	486,000	18.06	159.00	2,226.00	-----	11,162.16	0.8929	9,966.69
83	2	486,000	19.87	168.54	2,359.56	-----	12,184.92	0.7972	9,713.82
84	3	486,000	21.86	178.65	2,501.10	-----	13,303.71	0.7118	9,469.58
85	4	486,000	24.04	800 + 189.37	400 + 2,651.18	-----	15,723.99	0.6355	9,992.60
86	5	486,000	26.45	200.73	2,810.29	-----	15,865.72	0.5674	9,002.21
87	6	486,000	29.09	212.78	2,978.92	-----	17,329.44	0.5066	8,779.09
88	7	486,000	32.00	225.55	3,157.63	-----	18,935.18	0.4523	8,564.38
89	8	486,000	35.20	239.08	3,347.05	-----	20,693.33	0.4039	8,358.04
90	9	486,000	38.72	900 + 253.42	475 + 3,547.88	-----	23,994.22	0.3606	8,652.32
91	10	486,000	42.59	268.63	3,760.75	-----	24,728.12	0.3220	7,962.46
92	11	486,000	46.85	284.75	3,986.43	-----	27,040.28	0.2875	7,774.08
93	12	486,000	51.53	301.83	4,225.62	-----	29,571.03	0.2567	7,590.88
94	13	486,000	56.69	319.94	4,479.16	-----	32,350.44	0.2292	7,414.72
95	14	486,000	62.36	1000 + 339.14	550 + 4,748.03	-----	36,944.13	0.2046	7,558.77
96	15	486,000	68.59	359.48	5,032.79	-----	38,727.01	0.1827	7,075.43

P.W. TOTAL = $141,805.18

APPENDIX B

$P.W._N = FN (P/F, I, N)$

INFLATION RATE OF ELECTRIC POWER RATE IS 12%/YEAR

INFLATION RATE OF PERIODIC MAINTENANCE IS 6%/YEAR

YEARLY NATIONAL INFLATION RATE (I) IS 12%/YEAR

YEAR	N	CUBIC FEET OF HELIUM RECLAIMED PER YEAR	COST OF ELECTRIC POWER ($/1000 FT3)	PERIODIC MAINTENANCE COST		COST OF NEW EQUIPMENT	TOTAL COST (FN)	(P/F,I,N)	PRESENT WORTH I = 12%/YEAR
				COMPRESSOR	RECLAIMER				
81	0	486,000	16.42	150.00	2,100.00	1600+500+ 100+600+ 900	13,930.12	-------	13,930.12
82	1	486,000	18.39	159.00	2,226.00	-----	11,322.54	0.8929	10,109.90
83	2	486,000	20.60	168.54	2,359.56	-----	12,539.70	0.7972	9,996.65
84	3	486,000	23.07	178.65	2,501.10	-----	13,891.77	0.7118	9,888.16
85	4	486,000	25.84	800 + 189.37	400 + 2,651.18	-----	16,598.79	0.6355	10,548.53
86	5	486,000	28.94	200.73	2,810.29	-----	17,075.86	0.5674	9,688.84
87	6	486,000	32.41	212.78	2,978.92	-----	18,942.96	0.5066	9,596.50
88	7	486,000	36.30	225.55	3,157.63	-----	21,024.98	0.4523	9,509.60
89	8	486,000	40.66	239.08	3,347.05	-----	23,346.89	0.4039	9,429.81
90	9	486,000	45.53	900 + 253.42	475 + 3,547.88	-----	27,303.88	0.3606	9,845.78
91	10	486,000	51.00	268.63	3,760.75	-----	28,815.38	0.3220	9,278.55
92	11	486,000	57.12	284.75	3,986.43	-----	32,031.50	0.2875	9,209.06
93	12	486,000	63.97	301.83	4,225.62	-----	35,616.87	0.2567	9,142.85
94	13	486,000	71.65	319.94	4,479.16	-----	39,621.00	0.2292	9,081.13
95	14	486,000	80.25	1000 + 339.14	550 + 4,748.03	-----	45,638.67	0.2046	9,337.67
96	15	486,000	89.88	359.48	5,032.79	-----	49,073.95	0.1827	8,965.81

P.W. TOTAL = $157,558.97

APPENDIX B

$P.W._N = FN\ (P/F,\ i,\ N)$

INFLATION RATE OF ELECTRIC POWER RATE IS 15%/YEAR

INFLATION RATE OF PERIODIC MAINTENANCE IS 6%/YEAR

YEARLY NATIONAL INFLATION RATE (I) IS 12%/YEAR

YEAR	N	CUBIC FEET OF HELIUM RECLAIMED PER YEAR	COST OF ELECTRIC POWER ($/1000 FT3)	PERIODIC MAINTENANCE COST		COST OF NEW EQUIPMENT	TOTAL COST (FN)	(P/F,i,N)	PRESENT WORTH i = 12%/YEAR
				COMPRESSOR	RECLAIMER				
81	0	486,000	16.42	150.00	2,100.00	1600+500+ 100+600+ 900	13,930.12	-------	13,930.12
82	1	486,000	18.88	159.00	2,226.00	-----	11,560.68	0.8929	10,322.53
83	2	486,000	21.72	168.54	2,359.56	-----	13,084.02	0.7972	10,430.58
84	3	486,000	24.97	178.65	2,501.10	-----	14,815.17	0.7118	10,545.44
85	4	486,000	28.72	800 + 189.37	400 + 2,651.18	-----	17,998.47	0.6355	11,438.03
86	5	486,000	33.03	200.73	2,810.29	-----	19,063.60	0.5674	10,816.69
87	6	486,000	37.98	212.78	2,978.92	-----	21,649.98	0.5066	10,967.88
88	7	486,000	43.68	225.55	3,157.63	-----	24,611.66	0.4523	11,131.85
89	8	486,000	50.23	239.08	3,347.05	-----	27,997.91	0.4039	11,308.36
90	9	486,000	57.76	900 + 253.42	475 + 3,547.88	-----	33,247.66	0.3606	11,989.11
91	10	486,000	66.43	268.63	3,760.75	-----	36,314.36	0.3220	11,693.22
92	11	486,000	76.39	284.75	3,986.43	-----	41,396.72	0.2875	11,901.56
93	12	486,000	87.85	301.83	4,225.62	-----	47,222.55	0.2567	12,122.03
94	13	486,000	101.03	319.94	4,479.16	-----	53,899.68	0.2292	12,353.81
95	14	486,000	116.18	1000 + 339.14	550 + 4,748.03	-----	63,100.65	0.2046	12,910.39
96	15	486,000	133.61	359.48	5,032.79	-----	70,326.73	0.1827	12,848.69

P.W. TOTAL = $186,710.29

APPENDIX B

$P.W._N = FN\ (P/F,\ I,\ N)$

INFLATION RATE OF ELECTRIC POWER RATE IS 20%/YEAR

INFLATION RATE OF PERIODIC MAINTENANCE IS 6%/YEAR

YEARLY NATIONAL INFLATION RATE (I) IS 12%/YEAR

YEAR	N	CUBIC FEET OF HELIUM RECLAIMED PER YEAR	COST OF ELECTRIC POWER ($/1000 FT3)	PERIODIC MAINTENANCE COST		COST OF NEW EQUIPMENT	TOTAL COST (FN)	(P/F,I,N)	PRESENT WORTH I = 12%/YEAR
				COMPRESSOR	RECLAIMER				
81	0	486,000	16.42	150.00	2,100.00	1600+500+ 100+600+ 900	13,930.12	--------	13,930.12
82	1	486,000	19.70	159.00	2,226.00	-----	11,961.14	0.8929	10,680.11
83	2	486,000	23.65	168.54	2,359.56	-----	14,019.47	0.7972	11,176.32
84	3	486,000	28.37	178.65	2,501.10	-----	16,469.40	0.7118	11,722.92
85	4	486,000	34.05	800 + 189.37	400 + 2,651.18	-----	20,588.13	0.6355	13,083.76
86	5	486,000	40.86	200.73	2,810.29	-----	22,868.11	0.5674	12,975.37
87	6	486,000	49.03	212.78	2,978.92	-----	27,020.21	0.5066	13,688.44
88	7	486,000	58.84	225.55	3,157.63	-----	31,977.39	0.4523	14,463.38
89	8	486,000	70.60	239.08	3,347.05	-----	37,899.19	0.4039	15,307.48
90	9	486,000	84.72	900 + 253.42	475 + 3,547.88	-----	46,351.97	0.3606	16,714.52
91	10	486,000	101.67	268.63	3,760.75	-----	53,440.18	0.3220	17,207.74
92	11	486,000	122.00	284.75	3,986.43	-----	63,564.14	0.2875	18,274.69
93	12	486,000	146.40	301.83	4,225.62	-----	75,679.00	0.2567	19,426.80
94	13	486,000	175.68	319.94	4,479.16	-----	90,180.96	0.2292	20,669.48
95	14	486,000	210.82	1000 + 339.14	550 + 4,748.03	-----	109,095.40	0.2046	22,320.92
96	15	486,000	252.98	359.48	5,032.79	-----	128,342.15	0.1827	23,448.11

P.W. TOTAL = $255,090.14

APPENDIX B

COST ANALYSIS OF BUYING HELIUM OVER 15 YEARS

BROUGHT BACK TO A PRESENT WORTH

i Overall - 12 %/YR i' Delivery = 2.5 and 10 %/YR

$P.W._N = F_N$ (P/F, i %, N)

486,000 Cubic Feet Helium Purchased a Year Will Be Used to Be Comparable to the Amount of Gas Reclaimed.

Sample Calculation:

N = 5, i' = 2 %/YR, i = 12 %/YR

[(19.65 \$/1000 FT^3) + (35.00 \$/1000 FT^3)] (48600 FT^3 = F_5 = \$26559.90

(\$26,559.90) (P/F, 12, 5) = (\$26,559.90) (0.5674) = \$15,070.08

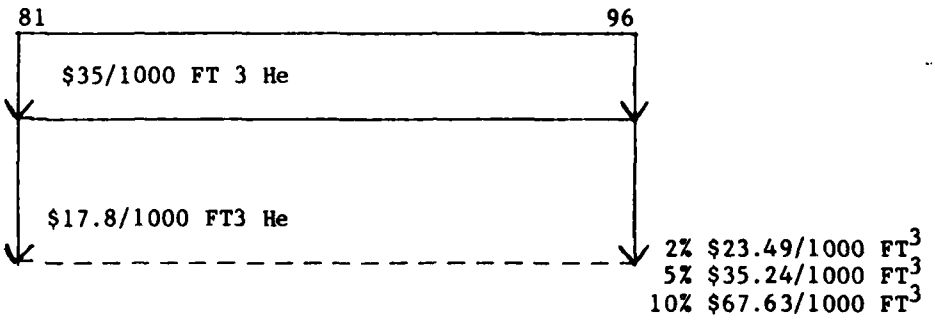
$P.W._N = P.W._{TOTAL}$

Future Worth:

F.W. = $(P.W._{TOTAL})$ (F/P, i %, N) ; i % = 12 %/YR, N = 15 YR

APPENDIX B

CASH FLOW HELIUM FROM TEXAS



Assumptions:

1. Life of equipment 15 years.
2. He price constant - $35/1000 FT^3.
3. Delivery of He at 2%, 5%, and 10% inflation per year.
4. Assume fee of $100/day trailer hold-over is negligible.

APPENDIX B

$I = 12\%/YEAR \quad I' = 2\%/YEAR \quad P.W._N = F_N\ (P/F, I, N)$

YEAR	N	CUBIC FEET OF HELIUM PURCHASED PER YEAR	COST OF DELIVERY ($/1000 FT3) (I = 2%/YR)	COST OF HELIUM ($/1000 FT3)	TOTAL COST (FN)	(P/F, I%, N)	PRESENT WORTH I = 12%/YEAR
81	0	486,000	17.80	35.00	25,660.80	-------	25,660.80
82	1	486,000	18.16	35.00	25,835.76	0.8929	23,070.42
83	2	486,000	18.52	35.00	26,010.72	0.7972	20,737.62
84	3	486,000	18.89	35.00	26,190.54	0.7118	18,642.96
85	4	486,000	19.27	35.00	26,375.22	0.6355	16,762.14
86	5	486,000	19.65	35.00	26,559.90	0.5674	15,070.86
87	6	486,000	20.05	35.00	26,754.30	0.5066	13,554.54
88	7	486,000	20.45	35.00	26,948.70	0.4523	12,188.88
89	8	486,000	20.86	35.00	27,147.96	0.4039	10,964.16
90	9	486,000	21.27	35.00	27,347.22	0.3606	9,860.94
91	10	486,000	21.70	35.00	27,556.20	0.3220	8,874.36
92	11	486,000	22.13	35.00	27,765.18	0.2875	7,984.98
93	12	486,000	22.58	35.00	27,983.88	0.2567	7,183.08
94	13	486,000	23.03	35.00	28,202.58	0.2292	6,463.80
95	14	486,000	23.49	35.00	28,426.14	0.2046	5,817.42
96	15	486,000	23.96	35.00	28,654.56	0.1827	5,234.22

P.W. TOTAL = $208,072.15

APPENDIX B

i = 12%/YEAR i' = 5%/YEAR $P.W._N = F_N$ (P/F, i, N)

YEAR	N	CUBIC FEET OF HELIUM PURCHASED PER YEAR	COST OF DELIVERY ($/1000 FT3) ($i$ = 2%/YR)	COST OF HELIUM ($/1000 FT3)	TOTAL COST (FN)	(P/F, i'%, N)	PRESENT WORTH i = 12%/YEAR
81	0	486,000	17.80	35.00	25,660.80	-------	25,660.80
82	1	486,000	18.69	35.00	26,093.34	0.8929	23,298.74
83	2	486,000	19.63	35.00	26,550.18	0.7972	21,165.80
84	3	486,000	20.61	35.00	27,026.46	0.7118	19,237.43
85	4	486,000	21.64	35.00	27,527.04	0.6355	17,493.43
86	5	486,000	22.72	35.00	28,051.92	0.5674	15,916.66
87	6	486,000	23.85	35.00	28,601.10	0.5066	14,489.32
88	7	486,000	25.05	35.00	29,184.30	0.4523	13,200.06
89	8	486,000	26.30	35.00	29,791.80	0.4039	12,032.91
90	9	486,000	27.61	35.00	30,428.46	0.3606	10,972.50
91	10	486,000	29.00	35.00	31,104.00	0.3220	10,015.49
92	11	486,000	30.44	35.00	31,803.84	0.2875	9,143.60
93	12	486,000	31.97	35.00	32,547.42	0.2567	8,354.92
94	13	486,000	33.57	35.00	33,325.02	0.2292	7,638.10
95	14	486,000	35.24	35.00	34,136.64	0.2046	6,984.36
96	15	486,000	37.01	35.00	34,996.86	0.1827	6,393.93

P.W. TOTAL = $221,998.05

APPENDIX B

I = 12%/YEAR I' = 10%/YEAR $P.W._N = F_N\ (P/F,\ I,\ N)$

YEAR	N	CUBIC FEET OF HELIUM PURCHASED PER YEAR	COST OF DELIVERY ($/1000 FT3) (I = 2%/YR)	COST OF HELIUM ($/1000 FT3)	TOTAL COST (FN)	(P/F, I%, N)	PRESENT WORTH I = 12%/YEAR
81	0	486,000	17.80	35.00	25,660.80	-------	25,660.80
82	1	486,000	19.58	35.00	26,525.88	0.8929	23,684.96
83	2	486,000	21.54	35.00	27,478.44	0.7972	21,905.81
84	3	486,000	23.69	35.00	28,523.34	0.7118	20,302.91
85	4	486,000	26.06	35.00	29,675.16	0.6355	18,858.56
86	5	486,000	28.67	35.00	30,943.62	0.5674	17,557.41
87	6	486,000	31.53	35.00	32,333.58	0.5066	16,380.19
88	7	486,000	34.69	35.00	33,869.34	0.4523	15,319.10
89	8	486,000	38.16	35.00	35,555.76	0.4039	14,360.97
90	9	486,000	41.97	35.00	37,407.42	0.3606	13,489.12
91	10	486,000	46.17	35.00	39,448.62	0.3220	12,702.46
92	11	486,000	50.79	35.00	41,693.94	0.2875	11,987.01
93	12	486,000	55.86	35.00	44,157.96	0.2567	11,335.35
94	13	486,000	61.45	35.00	46,874.70	0.2292	10,743.68
95	14	486,000	67.60	35.00	49,863.60	0.2046	10,202.09
96	15	486,000	74.36	35.00	53,184.96	0.1827	9,710.32

P.W. TOTAL = $254,200.74

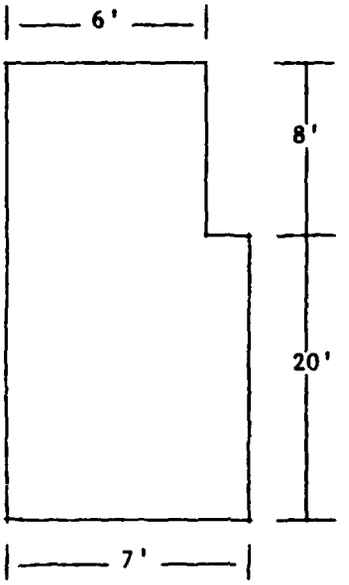
APPENDIX C

PROPOSED HELIUM COLLECTION BLADDER

APPENDIX C

PROPOSED REPLACEMENT HELIUM COLLECTION BLADDER

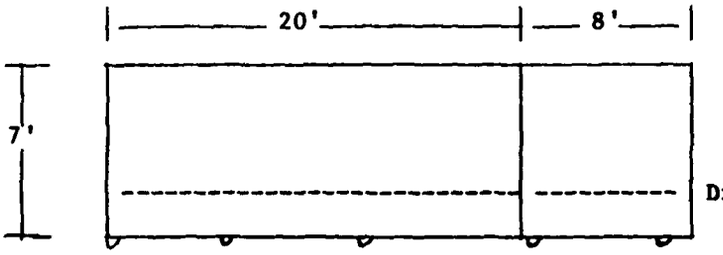
Top View



Dimensions

Length = 28 FT
Height = 7 FT
Width = 6 FT, 7 FT
Volume = 1316 FT^3

Side View



Tie Down Grommets Every 5 FT Along The Bottom Circumference


DATE
ILME
8